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Field bindweed (*Convolvulus arvensis*): "all tied up"

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> But your snobbiness, unless you persistently root it out like the bindweed it is, sticks by you till your grave. – George Orwell

> The real danger in a garden came from the bindweed. That moved underground, then surfaced and took hold. Strangling plant after healthy plant. Killing them all, slowly. And for no apparent reason, except that it was nature. – Louise Penny

Introduction

Field bindweed (*Convolvulus arvensis* L.) is a perennial vine in the Convolvulaceae, or morning-glory family, which includes approximately 50 to 60 genera and more than 1,500 species (Preston 2012a; Stefanovic et al. 2003). The family is in the order Solanales and is characterized by alternate leaves (when present) and bisexual flowers that are 5-lobed, folded/pleated in the bud, and trumpet-shaped when emerged (Preston 2012a; Stefanovic et al. 2003). Although many members of the Convolvulaceae are endemic to the tropics, genera have also evolved in Mediterranean and temperate regions. Plants in the Convolvulaceae can differ substantially with respect to their life-history traits; some are annual and perennial vines (e.g., *Ipomoea* spp., *Calystegia* spp.), others are leafless, parasitic plants (e.g., *Cuscuta* spp.) or woody shrubs (e.g., *Seddera* spp.), and there is even a tree (*Humbertia madagascariensis* Lam.). Although some species, like field bindweed, are significant weedy pests, others are desirable ornamentals (e.g., *Ipomoea tricolor* Cav.), medicinals [e.g., *Merremia tridentate* (L.) Hallier f.], or food crops [e.g., *Ipomoea batatas* (L.) Lam.].

Etymology

Field bindweed has been known by many different names over time (Mitich 1991), several of which reference the species' vining habit. For example, first century (C.E.) Greeks referred to it as the "curling plant" (*periklumenon*). Field bindweed's scientific name, *Convolvulus arvensis*, which was recorded in Linnaeus's *Species Plantarum* (1753), can be roughly translated as "to entwine the field." Nowick (2015) provides many historical names for field bindweed, including bearbind, bellbind, cornbind, corn-lily, creeping Jenny, European bindweed, European glory-bind, European morning glory, field-corn, hairy bindweed, hedgebell, lap-love, Nebraska glorybind, perennial morning-glory, sheep-bine, sheep-blue, small bindweed, Western bindweed, and with-wind. Other monikers include devil's guts and possession vine (Mitich 1991).

Description

The following description of field bindweed is compiled from multiple sources, including Holm et al. (1977), Preston (2012b), Uva et al. (1997) and Weaver and Riley (1982), as well as other citations in this article. Seedlings emerge primarily in the spring. Cotyledons are smooth and square to kidney shaped and are absent from plants emerging from perennial rhizomes. Leaves are alternate, smooth to hairy, and triangular to arrow shaped with entire margins and rounded apical tips; basal lobes point away from the stem. Leaf size (0.3 to 6 cm wide and 1 to 10 cm long) can vary significantly in response to environmental conditions such as moisture stress and light intensity. Stems are twisting, prostrate unless climbing, smooth to hairy, and up to 2 m (but sometimes more) long. Field bindweed produces vertical roots that can reach depths of 6 to 9 m, depending on soil type. It also has an extensive, adventitious, lateral root system that usually occupies the top 30 cm of soil. According to Bakke et al. (1944) and Frazier (1943), 50% to 70% of the species' underground biomass occupies the top 60 cm of the soil profile. Lateral roots are reported to grow 35 to 100 cm away from the parent plant before secondary vertical roots are formed. Root buds near the soil surface form new crowns, which give rise to vines, whereas deeper buds develop into rhizomes (Torrey 1958).

Perfect flowers (five stamens and a single stigma with two thin styles) are produced in leaf axils and are open for a single day. Flowers (1.5 to 2.5 cm in diameter) are white to pink, trumpet shaped, and fused at the base. Two leafy bracts (1 to 10 mm long) are present on the peduncle approximately 2.5 cm below the base of the flower. Flowering occurs from spring until frost; flowering plants have been seen in California's San Joaquin Valley in December (Sosnoskie, personal observation). DeGennaro and Weller (1984a) and Westwood et al. (1997a) reported that field bindweed is insect pollinated and self-incompatible. Fruit are rounded, grey to brown, papery capsules and generally hold up to four seeds. Seeds are 3 to 5 mm long, rough, brown to black, and rounded with two flattened sides. Seeds are viable within a month of pollination and, initially, are highly germinable; subsequent changes in seed moisture content and the permeability of the seed coat impose a dormancy that supports survival in soil for years and even decades (Brown and Porter 1942; Gehan Jayasuriya et al. 2008). Field bindweed seed production can vary across systems with published estimates ranging from 50,000 to 20 million seeds acre^{-1} (Brown and Porter 1942; Whitesides 1979). Bindweed seeds do not have specialized dispersal mechanisms and most fall close to the parent plant when shed. Seed movement may occur across short and long distances via machinery, through contamination of crop seed, or vectored via movement and migration after animal ingestion.

Field bindweed can be mistaken for several different weed species, including hedge bindweed [*Calystegia sepium* (L.) R. Br.] and wild buckwheat [*Fallopia convolvulus* (L.) Á. Löve] (Uva et al. 1997). Hedge bindweed is a perennial vine in the Convolvulaceae with stems that can be slightly less twisted and leaves that are typically larger, more pointed at the apex, and more deeply lobed at the base than those of field bindweed. Hedge bindweed also produces larger flowers with bracts that completely enclose the base of the corolla. Hedge bindweed styles are cylindrical as opposed to threadlike. Wild buckwheat, also referred to as black bindweed, is an annual vine in the Polygonaceae (smartweed family). Wild buckwheat stems are typically more delicate and branched than those of field bindweed. Characteristic of the Polygonaceae, a membranous ocrea encircles the base of wild buckwheat leaves, which are pointed at both the tip and the basal lobes. Wild buckwheat flowers are small and held in racemes as opposed to being produced singly in leaf axils.

History and Distribution

Field bindweed is native to the Mediterranean regions of Europe and Asia, although it now has a worldwide distribution (Preston 2012b); with respect to altitude, Khoshoo and Sachdeva (1961) reported finding the species at 3,000 m in the Himalayas. It was first introduced to the United States in 1739, possibly as a seed contaminant (Phillips and Timmons 1954). According to Kisselbach et al. (1934), bindweed was found throughout the Eastern seaboard by the early 1800s. By the start of the twentieth century, the species' range had expanded across the Midwestern states and to the Pacific Ocean (Mitich 1991). A search of herbarium records formally establishes field bindweed's presence in California in 1850 (San Diego County), although Rosenthal (1983) noted field bindweed was found in the bricks used to construct the Juan Jesus Vallejo

Field bindweed in Pima cotton in Merced County, CA.

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adobe in Fremont in 1838. For a more extensive review of field bindweed's spread in the United States, see the 1991 report by Mitich.

With respect to habitat, field bindweed grows in a variety of environments including lawns and gardens, roadsides and railways, industrial sites, pastures, annual cropping systems (especially under reduced tillage), and vineyards and orchards that are not heavily shaded (Weaver and Riley 1982). Field bindweed is considered intolerant to shade, although the species' climbing response is induced under low-light conditions (Bakke and Gaessler 1945; Gianoli 2001). According to Zouhar (2004), field bindweed has the potential to invade many types of ecosystems and plant communities after disturbance. Field bindweed can grow under a range of soil conditions, ranging from pH 4 to 9, fertile to nutrient-poor, and from moist (riparian and irrigated land) to dry (Tanveer et al. 2013) physiographic habitats. Because of its extensive root system, field bindweed is much less affected by drought than are many weed species (Weaver and Riley 1982). Conversely, field bindweed is relatively intolerant of wet or water-logged soils. Harvey (1959) reported that flooding for 60 to 90 days can suppress, although not control, vines.

Characteristics

Toxicity

Relatively little information is available about the impacts of field bindweed on livestock and wildlife, although data suggest its palatability and nutritive value may vary considerably among species that consume it. Allen (1968) and Taylor and Smith (2005) reported that whitetail deer and migratory birds may feed on bindweed shoots and roots. Singh (1962) found that sheep can consume bindweed foliage without detriment; Bell (1990), Georgia (1919), Shaw (1893) and Stahler and Carlson (1947) reported on the use of sheep grazing for vine suppression. Schutte and Lauriault (2015) evaluated the forage value of field bindweed roots and suggested that uprooted fragments could be nutritionally beneficial to some ruminants. Burrows and Tyrl (2001) concluded ingestion of small to moderate quantities by livestock may cause diarrhea, but consumption of large quantities or for prolonged intervals may result in decreased digestive tract motility. Horses and pigs, unlike sheep, may be sensitive to alkaloids present in bindweed shoots and roots (Callihan et al. 1990; Todd et al. 1995). Because the impermeability of bindweed seed supports survival after being ingested by an animal, it is possible that foraging on mature plants could facilitate propagule dispersal (Harmon and Keim 1934; Proctor 1968; Rolston 1978).

Weediness and Control

Field bindweed is a significant weedy pest in many annual and perennial crops, as well as in urban and industrial environments and even some natural areas, especially after disturbance. Field bindweed can reduce crop yields through direct competition; its vining habit also allows it to grow overtop of crops and impede the movement of harvest machinery in the field (Sosnoskie, personal observation). In Western rangelands, field bindweed infestations can reduce the diversity of native species and alter ecosystem functions (DiTomaso 2000). Although the economic implications of bindweed interference have not been regularly reported in scientific literature, Rosenthal (1983) and Boldt et al. (1998) suggested yield reductions in the United States can be considerable. Results from a survey of California agricultural commissioners and extension farm advisors estimated crop losses in response to bindweed at approximately \$25 million yr^{-1} (Rosenthal 1983). Boldt et al. (1998) reported that field bindweed infestations in the 10 most severely affected states resulted in crop losses that exceeded \$377 million yr^{-1}.

Field bindweed's weediness is directly related to its long-lived seeds and extensive root system. Field bindweed seeds are impermeable to water and can remain viable in the soil for many years (Brown and Porter 1942; Gehan Jayasuriya et al. 2008; Rolston 1978; Sripleng and Smith 1960; Timmons 1949; Whitesides 1979). Dormancy can be alleviated in the laboratory in several

Field bindweed flowers and flower buds.

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ways, including cold stratification, mechanical scarification, and treatment with sulfuric acid or boiling water; under field conditions, mechanical abrasion via soil disturbance and temperature fluctuations are likely responsible for mitigating dormancy (Brown and Porter 1942; Rolston 1978; Xiong et al. 2018). Although most bindweed seedlings emerge in spring and early summer (20 to 25 C is optimum), germination can occur over a wide range of temperatures (10 to 40 C) if enough moisture is available in the soil profile (Rolston 1978; Tanveer et al. 2013). Most seedlings emerge from seed burial depths no greater than 6 cm (Asgharipour 2011; Benvenuti et al. 2001). Management recommendations often suggest controlling field bindweed at the seedling stage, when the species is most susceptible to physical, chemical, and cultural control measures. This developmental phase, however, can be short-lived because seedlings develop regenerative root buds that support regrowth after defoliation within a month of emergence (Sosnoskie, personal observation; Weaver and Riley 1982).

The root system of field bindweed is also responsible for facilitating the species' survival and spread over time and space. Holdich and Sinclair (1826) stated that established field bindweed could not be controlled with ordinary weed-control methods. They suggested deep tillage combined with root-fragment removal for an entire fallow season followed by intensively cultivated crops. This recommendation was repeated in other early weed-management texts by Darlington (1847), Michener (1872), and Shaw (1893). Other research to evaluate field bindweed control found that multiple years of repeated (i.e., every 2 to 3 wk) soil disturbance were required to exhaust belowground energy reserves (Bioletti 1911; Frazier 1943; Timmons and Bruns 1951). Infrequent cultivation, however, may lead to the physical spread of root and rhizome pieces within and among fields (Buhler et al. 1994). Larger segments (with more root buds) and pieces originating from depths less than 20 cm in the soil are more likely to reestablish successfully than smaller fragments or fragments originating from deeper soil profiles (Omezine and Harzallah-Skhiri 2010; Sherwood 1945), although the timing of disturbance and seasonal variability in carbohydrate reserves may influence success (Barr 1940; Swan and Chancellor 1976; Willeke et al. 2015). For example, Willeke et al. (2015) reported that resprouting potential was greatest in April and May.

As an established perennial, systemic products (e.g., 2,4-D, dicamba, and glyphosate) are commonly recommended for managing perennial field bindweed vines, although, as with cultivation, repeated applications are often necessary, sometimes over years (Davison 1976; Hoss et al. 2003; Stone et al. 2005; Westra et al. 1992; Wiese and Lavake 1986; Wiese and Rea 1959). The control of field bindweed with systemic herbicides is not consistent throughout the year and can vary with the flow of assimilates to the root system, although vigorous, flowering plants have been reported to be most sensitive to treatment (Wiese and Lavake 1986; Wiese and Rea 1959). In addition to timing, herbicide efficacy can also be affected by diluent volume, adjuvant selection, growth conditions, and plant vigor at the time of application (Dall'Armellina and Zimdahl 1989; Duncan Yerkes and Weller 1996; Sherrick et al. 1986; Wiese and Lavake 1986). Differential susceptibility among bindweed populations in response to glyphosate and 2,4-D has also been reported (DeGennaro and Weller 1984b; Westwood et al. 1997b; Westwood and Weller 1997; Whitworth and Muzik 1967). Westwood et al. (1997b) and Westwood and Weller (1997) suggested that multiple mechanisms were contributing to the differences in glyphosate tolerance between their study biotypes. Although PRE-applied herbicides are mostly used to control bindweed seedlings, some products, like trifluralin, can suppress perennial vine emergence (Sosnoskie and Hanson 2016). Results from meta-analyses suggest that integrated practices, with or without herbicides, can be effective for managing field bindweed, although only a few studies have been conducted and few describe bindweed population dynamics over an extended time (Davis et al. 2018; Orloff et al. 2018).

Uses

Dioscorides, a Greek herbalist, suggested drinking a tea brewed from the seeds of field bindweed to treat hiccups, alleviate weariness, and treat spleen problems, but warned that continued consumption could result in blood in the urine and cause sterility (Mitich 1991). The use of bindweed as a laxative and diuretic was reported by Barker (2001) and Holm et al. (1977). Bindweed's arrival in Oregon was purportedly due to its purposeful planting as a cover crop in orchards (Swan 1980). Interviews with members of the Okanagan-Colville people in the Pacific Northwest indicate field bindweed historically has been used to make pack ropes (Turner et al. 1980). Members of the Ramah Navajo of western New Mexico used a cold infusion of the plant parts as a lotion for spider bites (Moerman 1998). A decoction made from plant parts was taken as a gynecological aid for excessive menstruation by members of the Ramah Navajo as well as the Kashaya Pomo, who inhabited the western coast of Sonoma County, CA.

Several species of bees have been associated with field bindweed flowers and foraged pollen, including honeybees (*Apis mellifera* L.) and sweat bees (Halictidae), among others (Abdel-Halim et al. 2013; Colteaux et al. 2013; O'Neal and Waller 1984; Pearce et al. 2012; Waddington 1976). Other insect species have also been reported foraging in field bindweed flowers, such as the beetle *Aethina concolor* (Macleay) (Logan and Rowe 2012). The adults and larvae of several tortoise beetles are known to feed destructively on the foliage, including golden tortoise beetle (*Charidotella sexpunctata* L.), Argus tortoise beetles (*Chelymorpha cassidae* Fab.), and mottled tortoise beetle (*Deloyala guttata* Olivier) (Hilty 2019). *Aceria malherbae* Nuzzaci (bindweed gall mite) infests both field and hedge bindweed (Boldt and Sobhian 1993; Boydston and Williams 2004; McClay et al. 1999). In addition to the presence of galls, which are abnormal swellings, on leaves and stems, signs of bindweed gall mite include stunted plants and reduced flowering. Larvae of the moth *Tyta luctuosa* Denis & Schiffermuller can also feed, nonselectively, on field and hedge bindweeds (Chessman et al. 1997). Fungal pathogens, including several members of Phaeosphaeriaceae have been investigated as possible mycoherbicides (Gomzhina et al. 2020; Heiny and Templeton 1991; Morin et al. 1989; Pfirter and Defago 1998).

The literature would suggest that, unlike many weeds, field bindweed can be successful in any manmade agricultural or landscape setting and in many natural settings. That it is such a successful weed in such diverse habitats enables it to keep mankind all tied up.

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